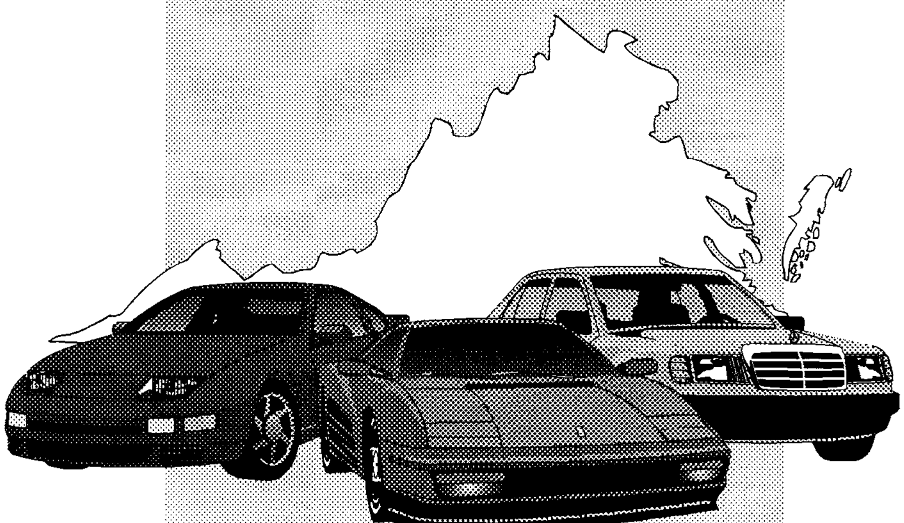
FINAL REPORT

THE EFFECTS OF MOTOR VEHICLE WINDOW TINTING ON TRAFFIC SAFETY AND ENFORCEMENT

A REPORT TO THE GOVERNOR AND GENERAL ASSEMBLY IN RESPONSE TO SENATE JOINT RESOLUTION 293, 1993 SESSION



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Supplementary Notes

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Abstract

The 1993 Session of the Virginia General Assembly lessened restrictions relating to the application of aftermarket tinted window films to motor vehicle glass. Effective July 1, 1993, vehicles are allowed to have window tinting treatments that do not reduce the transmittance of light below 35% for rear and rear side windows and 50% for front side windows, but no aftermarket tinting may be applied to windshields. However, the new legislation allows lower transmittance levels for the windows on vehicles used by individuals with a medical waiver.

The traffic safety community is concerned that aftermarket window tint film may increase the incidence of traffic crashes by limiting a driver's ability to see out of a vehicle, and it may compromise the safety of police officers by limiting an officer's ability to see into a vehicle that he or she has stopped. The window tinting industry, however, notes the lack of empirical evidence correlating window tinting and traffic crashes or police officer injuries or fatalities. The concerns of industry and the traffic safety community were balanced by the adoption of Senate Joint Resolution 293, which directed the Virginia Departments of Motor Vehicles and State Police to study the issue.

The study found that window tinting reduces the ability to detect targets that would be difficult to see through clear glass, and this can be a liability when ambient lighting is low. In addition, the adverse effects of window tinting become increasingly pronounced as transmittance goes below 70%, particularly for people who wear spectacles and for older drivers. There is no evidence, however, that reduced visibility significantly affects drivers' performance during well-illuminated daytime hours. The difficulties are more likely to be manifested at night. Further, by reducing the amount of light transmittance, window tinting reduces the ability of an outside observer to see into a vehicle, which has led to the concerns about the safety of police officers.

Although there are only limited optical benefits to be derived from window tinting and there are a number of potential optical detriments, there is no empirical evidence to indicate that the tinting allowed under Virginia's current laws creates a safety hazard in terms of driver performance. Thus, it is recommended that Virginia's new laws on window tinting not be changed unless compelling evidence that the standards compromise safety is found in the future. However, further research is recommended. It is also recommended that federal regulations and/or action by the states to achieve national uniformity be encouraged in order to promote uniformity in laws and regulations concerning aftermarket window tinting.

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PREFACE

The 1993 session of the Virginia General Assembly adopted Senate Joint Resolution 293 (SJR 293), sponsored by Senator Charles L. Waddell. SJR 293 directed the Virginia Department of Motor Vehicles (DMV) and the Virginia State Police to conduct a study of Virginia's laws relating to tinted motor vehicle glass and the enforcement of these laws. Associated with this issue is a long-standing debate between the traffic safety community and the window tinting industry. The traffic safety community is concerned that aftermarket window tint film may increase the incidence of traffic crashes by limiting a driver's ability to see out of a vehicle, and it may compromise the safety of police officers by limiting an officer's ability to see into a vehicle that he or she has stopped. The window tinting industry, however, notes the lack of empirical evidence correlating window tinting and traffic crashes or police officer injuries or fatalities.

The DMV and the State Police requested that the Virginia Transportation Research Council conduct the study with the advice of a steering committee led by the State Police. The steering committee was a diverse group that included representatives from the enforcement and regulatory communities, the window tinting industry, the traffic safety community, the military, and transportation research. Although the contents of the report and its conclusions and recommendations are solely the responsibility of the authors, the report was adopted by the steering committee by unanimous consent.

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EXECUTIVE SUMMARY

All across the United States, the issue of whether motor vehicle window tinting should be allowed and how much tinting should be allowed has been the source of fractious debate in state legislatures. Federal regulations govern all matters concerning motor vehicle window glass for new vehicles. Except for motor vehicle glass that is installed behind the driver in trucks, buses, and multi-purpose vehicles, the glass on all motor vehicles must allow for at least 70% of the light to pass through. However, there are no federal standards that apply to aftermarket applied window tint films.

There is a demand for tinted window films. The window film industry argues that window tinting creates lower interior vehicle temperatures, minimizes sun-related damage to upholstery and dashboards, provides protection for persons harmed by, or sensitive to, sunlight, and adds some measure of privacy to the vehicle. Also, tinting may enhance the aesthetic appeal of a vehicle, especially when color coordinated with the vehicle's exterior paint.

The enforcement and traffic safety communities, on the other hand, take strong exception to the use of what they might consider excessively dark window films. There is the belief that window tinting may increase the incidence of traffic crashes. Also, dark window films are considered to be a threat to the safety of police officers. There is a desire to afford police officers the opportunity to see contraband or what might be the threatening actions of a person who may be obscured by darkly tinted glass.

In the 1993 Session of the General Assembly, measures designed to change Virginia's laws relating to the application of aftermarket tinted window films to motor vehicle glass were debated. House Bill 1990 (HB 1990), which lessened Virginia's restrictions on tinted glass for vehicles, was passed. As a result, effective July 1, 1993, vehicles are allowed to have window tinting treatments that do not reduce the transmittance of light below 35% for rear and rear side windows and 50% for front side windows. However, no aftermarket tinting may be applied to windshields. House Bill 1436 (HB 1436) also was passed; it allowed individuals with a medical waiver to apply tinted window film on the windshield to reduce total light transmittance to as low as 70% and on other windows to as low as 35% in the vehicles in which they generally travel.

The concerns of industry and the traffic safety community were balanced by the adoption of Senate Joint Resolution 293 (SJR 293). This resolution directed the Virginia Departments of Motor Vehicles (DMV) and State Police (VSP) to "examine Virginia's laws relating to tinted motor vehicle glass and related subjects and the enforcement of these laws and make such legislative and other recommendations as may be appropriate."

The study found that there is no pattern that characterizes the various state laws on window tinting. Virginia's current laws on window tinting are more restrictive than those of 27 states and less restrictive than those of 8 others, with the remaining 14 states having greater restrictions on some windows and less on others. However, the 1993 changes to Virginia's window tinting laws have facilitated enforcement by authorizing the Division of Purchases and Supply to establish standards for equipment to measure light transmittance, which has resulted in permitting the use of a meter to test light transmittance for evidentiary purposes. A survey of 10 state motor vehicle inspection stations revealed that over 80% of the surveyed vehicles that had aftermarket window tinting were in violation of Virginia's new law. The average level of light transmittance on tinted front side windows was 33% and that for rear side windows was 27%.

The study also found that window tinting reduces the ability to detect targets that would be difficult to see through clear glass, and this can be a liability when ambient lighting is low. In addition, the adverse effects of window tinting become increasingly pronounced as transmittance goes below 70%, particularly for people who wear spectacles and for older drivers. There is no evidence, however, that reduced visibility significantly affects drivers' performance during well-illuminated daytime hours. The difficulties are more likely to be manifested at night.

By reducing the amount of light transmittance, window tinting reduces the ability of an outside observer to see into a vehicle, which has led to the concerns about the safety of police officers. However, window tinting also diminishes the ability to see into a tinted vehicle in part by increasing reflectance. Reflected light masks the transmitted light in proportion to the ratio of reflected to transmitted light. Thus, window tinting reduces the amount of light emanating from the interior of a vehicle while increasing the proportion of light reflected off of its surface from the outside. Unfortunately, because the disruptive effects of reflections are situationally specific, it is not possible to determine whether Virginia's new laws compromise the safety of police officers.

On the other hand, window tinting can reduce discomfort glare, which is the unpleasant feeling that accompanies exposure to a source of glare. Further, window tinting films do not reduce contrast. Since window tinting films reduce transmittance proportionately, the target/background contrast is constant across all transmittance levels. Also, window tinting has been shown to reduce vehicle interior temperatures.

Although there are only limited optical benefits to be derived from window tinting and there are a number of potential optical detriments, there is no empirical evidence to indicate that the tinting allowed under Virginia's current laws creates a safety hazard in terms of driver performance. Thus, it is recommended that Virginia's new laws on window tinting not be changed unless compelling evidence that the standards compromise safety is found in the future. However, further research is recommended on the effect of window tinting on facial communication, the performance of drivers, and the safety of police officers.

It is also recommended that federal regulations and/or action by the states to achieve national uniformity be encouraged in order to promote uniformity in laws and regulations concerning aftermarket window tinting. Such action would remove the burden of changing applications of window tinting by military personnel and other individuals who relocate from one state to another.

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INTRODUCTION

Throughout the United States, the traffic safety community has lobbied state legislatures for restrictions on motor vehicle window tinting. One reason for such restrictions is the desire to provide police officers enough light to afford them the opportunity to see into other vehicles for their own safety. In addition, many people believe that there is a link between window tinting and the incidence of traffic crashes. A concern is that window tinting may reduce the driver's visibility and make it difficult for a driver to identify low contrast objects, especially at night. A related concern is that tinted vehicle glass may reduce the amount of eye contact that can be made between a driver and other drivers, pedestrians, and bicyclists. Those voicing this concern believe that the loss of visual communications may result in a lack of communication of intent between drivers and other highway users.

The window tinting industry, however, notes the lack of empirical evidence to correlate window tinting and traffic crashes or police officer injuries or fatalities. The tinting industry also points to the many benefits of window tinting, which include increased privacy and aesthetic appeal, lower interior vehicle temperatures, reductions in the fading of upholstery, and additional protection for persons with eye or skin disorders that make them sensitive to sunlight.

With the amount of controversy surrounding this issue, it is not surprising that window tinting is regulated by both federal and state law. Federal standards apply to maximum levels of tinting that may be incorporated into motor vehicle glass from the vehicle's manufacturer. Also, many states have elected to regulate the level of light transmittance of aftermarket tinting film that may be applied to a motor vehicle by the vehicle's owner. A result of these policies is that the public, especially those who bring vehicles into a state that has relatively strict laws from a state where window tinting laws are not as strict, are vocal in their complaints about inconsistent and changing laws and regulations. These individuals may be required to remove tinting that is not in compliance, which can damage a vehicle's rear window defroster.

In the 1993 session of the General Assembly, measures designed to change Virginia's laws relating to tinted vehicle windows were debated. House Bill 1990 (HB 1990), which lessened the restrictions on tinted glass for vehicles, was passed. As a result, effective July 1, 1993, vehicles are allowed to have window tinting treatments that do not reduce the transmittance of light below 35% for rear and rear side windows and 50% for front side windows. No aftermarket tinting may be applied to the windshield (see Appendix A).

House Bill 1436 (HB 1436) was also passed; it allowed individuals with a medical waiver to apply tinted window film on the windshield to reduce total light transmittance to as low as 70% and on other windows to as low as 35% in the vehicles in which they generally travel. Prior to the passage of this bill, the level of tinting allowed was at the discretion of the Superintendent of State Police. The new standard became effective July 1, 1993. Also, window treatments may be applied if a certificate is issued by the Superintendent of State Police in accordance with a physician's or optometrist's written statement (see Appendix A).

STATEMENT OF THE PROBLEM

There are many reasons why people desire tinted glass on their vehicles. Some people have medical conditions that make their skin or their eyes sensitive to sunlight. Individuals with disorders that compromise their immune systems often must avoid exposure to sunlight. Some people, particularly those who live in hot climates and frequently leave their vehicles in direct sunlight, argue that tinted glass helps to reduce the interior temperature of their vehicles. Finally, there are those individuals who simply desire more privacy in their vehicles than that afforded by clear glass.

The law enforcement community, however, has had longstanding objections to the widespread use of tinted glass in motor vehicles. In fact, the International Association of Chiefs of Police (IACP) has offered several resolutions recommending that window tinting treatments be disallowed. First, the use of tinted glass reduces the amount of light that can be detected within a treated automobile. Although in bright light a driver may have enough light available from outside the vehicle to see clearly, tinted windows may reduce visibility in the dark or in inclement weather to such an extent that a driver may not be able to see clearly. Comparisons are often made between the use of tinted glass at night and the use of sunglasses at night, with the important difference that one cannot remove window tinting at night.

A related concern is that tinted glass may create a traffic safety problem by reducing the amount of eye contact that can be made between drivers and pedestrians. Those voicing this concern believe that the loss of visual communication may result in a complete lack of communication of intent between drivers and pedestrians.

Another concern expressed by the traffic safety community involves police officer safety. Officers are concerned when they are not able to clearly see into a vehicle with tinted glass, particularly at night. It is easier for a driver or passenger of a vehicle with tinted windows to conceal a weapon and ambush an officer as he or she approaches the vehicle. How much easier, of course, would depend upon the degree of tinting.

The concerns of the industry and the traffic safety community were balanced by the adoption of Senate Joint Resolution 293 (SJR 293), which commissioned a study of the issues associated with the tinted glass debate. Specifically, SJR 293 directed the Virginia Departments of Motor Vehicles (DMV) and State Police (VSP) to "examine Virginia's laws relating to tinted motor vehicle glass and related subjects and the enforcement of these laws and make such legislative and other recommendations as may be appropriate" (see Appendix A).

The VSP and DMV requested that the Virginia Transportation Research Council (VTRC) work with a steering committee composed of officials from both agencies and chaired by Lt. Col. C. M. Robinson of the VSP. The VTRC was asked to conduct a study to address the issues relevant to the use of tinted glass in motor vehicles. This document is the VTRC's final report, and it was adopted unanimously by the steering committee.

METHODS

Task 1: Current Status of Window Tinting in Virginia and the Nation

The first task was to determine the extent of the problems that had historically been linked with window tinting. A survey of the state police of the 50 states was conducted to identify any studies that directly correlated window tinting with increases in traffic crashes or police officer injuries or fatalities. Second, a thorough review and analysis of the Virginia statutes and the case law developed from them was conducted. The laws of the other 49 states were also reviewed and compared to those of Virginia. In order to determine the extent of window tinting in the Commonwealth, a survey of both urban and rural inspection stations was conducted to estimate the percentage of vehicles with aftermarket tinting applications, the average level of light transmittance of these tinting applications, and the percentage of vehicles in violation of the new standard.

Task 2: Review of the Literature

The next task was to conduct a search of the literature to determine the state of knowledge of a number of issues germane to the topic of tinted glass in vehicles. These issues included a summary of the optics of window tinting, the physiological impact of a reduction of light on the driver, the impact of tinted glass on the visibility both from within and from the outside of the vehicle, the protection from heat afforded by tinted glass, and the differing impact of various lighting conditions on visibility when tinted glass is used. In addition, the review of the literature was designed to determine whether there are any interactive effects of the age of the driver and the use of glass tinting in vehicles. The assistance of a psychologist specializing in lighting and vision was solicited to interpret the findings of previous research and to identify areas where additional testing is needed.

Task 3: Observations of the Optical Qualities of Aftermarket Tinted Window Film

Aftermarket tinting was applied to a state-owned vehicle, thereby lowering the total light transmittance of the windows to the minimum permitted under legal requirements of the current legislation. The vehicle was driven at various times of the day to determine whether there were any differences in visibility between this vehicle and an identical vehicle with no aftermarket tinting.

FEDERAL AND STATE LAWS

Federal safety standards applicable to vehicles are covered by the National Traffic and Motor Vehicle Safety Act (NTMVSA) of 1966. NTMVSA directed the Secretary of Transportation to develop and enforce uniform national safety standards. One intent of the NTMVSA of 1966 was to enact a uniform set of standards for the country and to limit the states' rights to deviate from federal standards. A state is not permitted to enforce any standard that is not identical with the federal standard in any area in which federal law is in effect.

Currently, the federal standard for light transmittance follows the "recommended practice of the Society of Automotive Engineers by incorporating the performance criteria and tests of the American National Standards Institute for automotive glazing." The standard requires vehicle manufacturers to ensure that all motor vehicles (with the exception of trucks, buses, and multipurpose vehicles) have a minimum light transmittance of 70% (i.e., 70% of the light must pass through the glass) for all windows. Trucks, buses, and multipurpose vehicles have no minimum transmittance requirement for the rear and rear side windows. These federal standards do not apply to the aftermarket application of tinted window films.

Proposed Change in Federal Law

In 1991 the National Highway Traffic Safety Administration (NHTSA) proposed an amendment to the federal standard that would (1) lower the transmittance rates from 70% for all windows to 60% for the front and front sides, 50% for the rear window, and 35% for the rear side windows and (2) hold buses, trucks, and multipurpose vehicles to the standard. The proposed amendment would also change the current method of measuring light transmittance. This amendment would not affect state regulation of aftermarket tinting; thus, it would have little effect on state law. However, this proposal to amend the federal standard seems to have been abandoned.

Recent Changes in Virginia's Laws Concerning Window Tinting

Virginia has regulated aftermarket window tinting for decades, but it was not until 1991 that the General Assembly introduced minimum transmittance levels. These changes were codified in Code of Virginia § 46.2-1052. The window tinting statute severely limited the amount of tinting that could be applied. For most people, no aftermarket tinting could be applied at all to the windshield. If a vehicle was equipped with a mirror on each side that would reflect at least 200 ft to the rear of the vehicle, tinting could be applied to the front and rear side windows and the rear window. A single layer of tinting could be applied if the luminous transmittance of the layer was at least 35% for the rear and rear side windows and 70% for the front side windows. A person could apply a layer of tinting to a vehicle that already had tinting in the glass, thereby effectively lowering the total light transmittance of the glass to a percentage as low as 24.5% for the rear and rear side windows (70% X 35%) and 49% for the front side windows (70% X 70%).

The type of tinting material applied and the method of enforcement was left to the Superintendent of State Police. To enforce the statute, the Superintendent required a Vehicle Approved Tinting (VAT) decal to be displayed underneath the tinting film. The type of VAT decal used indicated the amount of light transmittance of the film. For example, VAT 1 allowed light transmittance of 70%; VAT 2 allowed 68%; and VAT 3 allowed 35%. Anyone placing the wrong layer of tinting on the window, placing the decal in the wrong place, using a decal that indicated a light transmittance level inconsistent with the actual light transmittance level, or simply failing to display the decal could be cited for an equipment violation. For the first violation, the fine would not exceed $100; for the second violation, the tinting might have to be removed in addition to any fine assessed. Unfortunately, VAT decals were easy to obtain, and it was rather simple for a person to circumvent this regulation by placing the appropriate decal beneath nonconforming tinting film.

A medical exception was provided by the Code (Va. Code Ann. § 46.2-1053. Michie Supp. 1993) for persons with skin or eye disorders. If a person obtained a written statement from his or her physician or optometrist explaining a need for window tinting, the Superintendent of State Police could issue a special permit that allowed that person to tint their windows and their windshield below the allowed light transmittance levels. The amount of light transmittance allowed was left to the discretion of the Superintendent.

Two bills affecting window tinting standards were passed in the 1993 session of the Virginia General Assembly. The first, HB 1990, amended the Code as it relates to the application of aftermarket window tinting films. This amendment made four important changes in the current law. First, the amendment allows the rear and rear side windows to be tinted as long as they maintain a total light transmittance of no less than 35%, and the front side windows are now permitted to have a total light transmittance as low as 50%. The statute codifies a 7 percentage point margin of error, thereby effectively lowering the light transmittance to 28% for the rear and rear sides and 43% for the front sides. Thus, it appears the new legislation may require a stricter standard for the rear and rear side windows and a standard for the front side windows that is only marginally lower. Second, the bill limits the reflection of light from the windows to 20% (i.e., only 20% of the light may be reflected outward) on vehicles that have aftermarket window tinting. There was no limitation of reflectance in the previous statute. Third, a first violation of this statute will be punished as a

Class 3 Misdemeanor, whereas subsequent violations will be punished as Class 2 Misdemeanors. No demerit points will be awarded for violations of this amendment. Thus, a person can now receive up to a $500 fine for a first offense and up to six months in jail in addition to any fine for any subsequent offenses. This amendment makes a tinting violation far more serious than it was under the previous law. Fourth, the Division of Purchases and Supply was directed to certify the appropriate testing measures to enforce violations of these laws. The Division of Purchases and Supply certified the "Tint Meter," a device that can be placed on the side windows to measure the total light transmittance of the glass. Although this device is not able to measure windows that cannot be rolled down, it is a much more reliable enforcement tool for state police officers. The VSP is currently reviewing possible devices to measure windows that cannot be rolled down. However, it is clear that the change in the law that specified levels of total light transmittance and the use of the tint meter has reduced some of the ambiguities of the previous law.

The second bill on window tinting passed in the 1993 session was HB 1436, which amended the portion of the Code that created a medical exemption for window tinting (Va. Code § 46.2-1053). Under this bill, persons with a medical disability are now permitted to apply tinting on any of their windows and their windshield as long as the tinting does not reduce the light transmittance level below 35% and they either (1) obtain approval from the Superintendent of State Police or (2) had the tinting installed in another state and have a minimum transmittance level of 70% for the windshield and 35% for all other windows. In either case, the person will be required to have a written statement from his or her physician or optometrist.

LEGAL ISSUES SURROUNDING WINDOW TINTING

After reviewing the legal literature concerning the application of aftermarket tinting, two issues emerged: federal preemption (both constitutionally and by statute) and an exemption for active duty military personnel.

The constitution grants the federal government the power to regulate commerce. The courts have interpreted this grant of authority to simultaneously limit the state's ability to regulate commerce. The Dormant Commerce Clause is invoked when a state attempts to regulate an area of commerce the court feels should be left to the federal government. Traditionally, at least in the context of safety regulations, the courts have applied a balancing test that weighs the burden on interstate commerce against the state's interest in safety. *Southern Pacific Co. v. Arizona*, 365 U.S. 761 (1945). Since there is relatively no burden on interstate commerce, if it is determined that a state has a legitimate interest in restricting aftermarket tinting, the law will probably be upheld. The federal standard has limited application to commercial trucks and multipurpose vehicles, so if tinting were important to a company, it could purchase windows with tinting in the glass. This is not a situation in which a company would be forced to comply with two conflicting statutes. *See Bibb v. Navajo Freight Lines, Inc.* 359 U.S. 520 (1959) (holding Pennsylvania statute unconstitutional where Pennsylvania required curved mudguards and Arizona required square mudguards).

In addition, the Supreme Court has increasingly given greater deference to state safety regulations unless they are discriminatory in nature. *See Kassel v. Consolidated Freightways Corp,* 450 U.S. 662 (1981), *See also Raymond Motor Transportation, Inc. v. Rice,* 434 U.S. 429 (1978). The window tinting law will be applied uniformly and will not have a disparate impact on nonresidents.

NTMVSA may also preempt state regulation of aftermarket tinting. NTMVSA, however, only applies to manufacturers and dealers of motor vehicles and motor vehicle equipment. Thus, someone who purchases a motor vehicle for purposes other than resale will be permitted to tint the windows of the vehicle even if in so doing the level of tinting would violate the federal standard regulating manufacturers. NTMVSA attempts to limit this practice by prohibiting a manufacturer, dealer, or motor vehicle repair business from "rendering inoperative" a vehicle that complies with federal standards. The only federal case on this topic, *U.S. v. Blue Skies Projects, Inc. 785 F Supp. 957 (1991),* held that a "tinting shop" is not a motor vehicle repair business for purposes of NTMVSA. Id at 957. Thus, a person may either apply tinting to his vehicle himself or have a tinting shop do it for him without violating federal law. Since aftermarket tinting, at least in the above context, is not regulated by the federal government, the state may regulate this activity in any manner it chooses.

The military issue is a major concern for Virginia because of the numerous military establishments within the state. Window tinting laws may have a disproportionate impact on persons from out of state coming to reside in Virginia. This is especially true of active duty military personnel residing in the state, many of whom are domiciled in other states that allow aftermarket tinting with light transmittance levels below Virginia's standard. Although states are barred by the Soldiers and Sailors Relief Act (SSRA) (50 USCA Appx 574) from taxing active duty military personnel based on residency, this act does not relieve military personnel of the responsibility to adhere to local laws. The purpose of SSRA was to relieve nonresident servicemen of the burden of supporting state governments where they reside solely by reason of their compliance with a military order. *California v. Buzard* 382 U.S. 386, (1966). The act does not deal with compliance with state and local ordinances; thus, the SSRA does not prevent the states from applying window tinting laws equally to residents and military personnel. There is, however, a common law immunity afforded military personnel. As a general rule, a "federal officer, who while performing a federal duty runs afoul of state law is immune from state prosecution." *State of Mon-*

tana v. Christopher, 345 F. Supp. 60, 61 (1972). In *Christopher*, an enlisted soldier was given immunity when he received a citation for a broken taillight. Christopher had informed his superiors of the problem, but was ordered to drive the nonconforming vehicle anyway because of a pending emergency. However, as recently pointed out by the district judge for the eastern district of Virginia, this immunity is not applicable where the soldier is under no duty to drive. (Id.) at 61. *Commonwealth v. Harvey*, 571 F. Supp. 464-465. This interpretation has been consistently confirmed by the Supreme Court. In a recent Supreme Court case on this issue, the court held that "the policy considerations which compel civil immunity for certain governmental officials [do not] place them beyond the reach of the criminal law." *Mesa v. California*, 489 U.S. 121, 1989 (citing *Imbler v. Pachtman*, 424 U.S. 409, 429. [1976]). Thus, this limited immunity should not affect the application of the state's tinting law as applied to the personal vehicles of active duty military personnel. Only in an emergency in which the soldier was under orders to use a personal vehicle that did not conform to state standards may the immunity be invoked.

Comparison between Window Tinting Laws in Virginia and Other States

As can be seen in Table 1, there is no typical pattern that characterizes the various state laws and regulations on window tinting. However, there are some basic similarities between the states concerning their regulation of aftermarket window tinting. For example, 37 states other than Virginia now regulate aftermarket window tinting transmittance by statute instead of administrative rules. Additionally, 41 states will not allow the application of tinting on the windshield. Of the nine states that do permit windshield tinting, 5 authorize transmittance of 70%, 4 authorize 35% transmittance, and 3 states have a reflectance value of 35%. Most states do, however, allow individuals to tint the uppermost portion of the windshield.

The regulation of the remaining categories of window (front-side, rear-side, and rear) have a much wider range of regulation. Of the 34 states specifying a level of transmittance for front-side and rear-side windows, levels range from 15% to 73%, but 26 of the states have levels between 20% and 35%. Of the 32 states specifying a level of transmittance for rear windows, levels range from 10% to 70% with 22 states mandating levels between 20% and 35%. A transmittance and/or reflectance value of 35% is the most common value for all categories of windows. Overall, Virginia's new laws on minimum levels of light transmittance are more restrictive than the laws of 27 states and less restrictive than the laws of 8 others, with the remaining 14 states having greater restrictions on some windows and/or less on others.

It cannot be overemphasized that absent these basic similarities there is a general lack of consensus in both the allowable transmittance levels, the treatment of reflectance, and the manner in which the window tint is actually

Table 1
WINDOW TINTING LAWS AND REGULATIONS:
MINIMUM LIGHT TRANSMITTANCE AND MAXIMUM REFLECTIVITY

State	Method Of Promulgation	Wind-shield	Front Sides	Rear Sides	Rear Window	Reflectivity
Alabama[a]	Administrative	NTA[b]	32%	32%	32%	NR[c]
Alaska	Administrative	NTA	38%	25%	10%	NR
Arizona	Statute	NTA	35%	35%	35%	NR
Arkansas[d]	Statute	NTA	25%	25%	10%	NR
California	Statute	NTA	NTA	NR	NR	NR
Colorado	Statute	70%	27%	NR	NR	NR
Connecticut	Statute	NTA	73%	35%	35%	NR
Delaware	Administrative	NTA	NTA	NR	NR	NR
Florida	Statute	NTA	28%	15%	15%	NR
Georgia	Statute	NTA	32%	32%	32%	20%
Hawaii	Statute	NTA	35%	35%	35%	NR
Idaho	Statute	NTA	35%	20%	35%	35%
Illinois	Statute	NTA	NTA	NR	NR	NR
Indiana	Statute	35%	35%	NR	35%	NR
Iowa	Administrative	NTA	NTA	NTA	NR	NR
Kansas	Statute	NTA	35%	35%	35%	0%
Kentucky	Statute	NTA	35%	18%	18%	25%/35%
Louisiana	Statute	NTA	40%	25%	12%	20%
Maine	Statute	NTA	50%	50%	50%	0%
Maryland	Administrative	NTA	35%	35%	35%	NR
Massachusetts	Statute	NTA	35%	35%	35%	35%
Michigan	Statute	NTA	NTA	NR	NR	35%
Minnesota	Statute	NTA	50%	50%	50%	20%
Mississippi	Statute	NTA	35%	35%	35%	20%
Missouri	Statute	NTA	NTA	NR	NR	NR
Montana	Statute	35%	20%	20%	20%	35%
Nebraska	Statute	NTA	35%	20%	20%	35%
Nevada	Administrative	NTA	35%	35%	35%	NR
New Hampshire	Statute	NTA	NTA	35%	35%	NR
New Jersey	Statute	NTA	NTA	NR	NR	NR
New Mexico	Statute	NTA	NTA	NR	NR	NR
New York	Statute	70%	70%	70&	70%	NR
North Carolina	Statute	NTA	50%	50%	50%	20%
North Dakota	Statute	70%	70%	20%	20%	NR
Ohio	Statute	70%	50%	50%	50%	0%
Oklahoma	Statute	NTA	35%	20%	20%	20%
Oregon	Administrative	NTA	NTA	50%	NTA	NR
Pennsylvania	Statute	NTA	NTA	NR	NR	NR
Rhode Island[e]	Administrative	NTA	NTA	NR	NR	NR
South Carolina	Statute	NTA	27%	27%	20%	0%
South Dakota	Statute	35%	35%	35%	NR	NR
Tennessee	Statute	70%	35%	35%	35%	NR
Texas	Statute	35%	35%	35%	NR	NR
Utah	Administrative	NTA	NTA	NR	NR	NR
Vermont	Administrative	NTA	NTA	NR	NR	NR
Virginia	Statute	NTA	50%	35%	35%	35%

continues

Table 1
WINDOW TINTING LAWS AND REGULATIONS:
MINIMUM LIGHT TRANSMITTANCE AND MAXIMUM REFLECTIVITY (Continued)

State	Method Of Promulgation	Wind-shield	Front Sides	Rear Sides	Rear Window	Reflectivity
Washington	Statute	NTA	35%	35%	35%	20%
West Virginia	Statute	NTA	35%	35%	35%	20%
Wisconsin	Administrative	NTA	NTA	NR	NR	NR
Wyoming	Administrative	NTA	NR	NR	NR	NR

[a]The Alabama Supreme Court recently ruled the state's law unconstitutionally vague. Also, the court ruled that the Department of Public Safety acted unconstitutionally by attempting to circumvent the legislative process in establishing percentage levels for transmittance.
[b]NTA = No tinting allowed.
[c]NR = No restriction.
[d]Statute applies to 1994 model cars and after.
[e]The figures correspond to rates currently in effect. According to the Rhode Island Department of Transportation's Office of Legal Counsel and the Office of Inspection in telephone interviews conducted on October 27, 1993, the laws will change in January 1994 to prohibit tinting on all windows.

measured. These problems make it very difficult for the average motor vehicle operator to determine the amount of tinting he or she may apply to his vehicle if he or she plans to operate it outside his or her own state. Clearly, a federal standard, or, alternatively, a national standard produced and implemented by the states through an interstate compact would serve to bring about consistency in the various states' window tinting statues.

SURVEY OF OTHER STATES

A survey of all 50 states was conducted to identify any studies that directly linked window tinting to the incidence of traffic crashes or to police officer injuries or fatalities. The initial contact with each state was made with that state's Department of Public Safety, which is usually a division of the State Police. States in which a window tinting law had recently been passed or where a new law had been proposed tended to have knowledgeable representatives in the State Police as well as in other agencies. Although many states were in the process of reviewing their window tinting statutes, none of the states had any hard data linking window tinting to any crashes or officer injuries or fatalities. Two states, Wyoming and Hawaii, are in the process of attempting to track crashes related to window tinting, but they have yet to come up with a single case.

Most of the available information on crashes and officer injuries or fatalities in which window tinting was a factor is anecdotal in nature. Generally, states have no way to indicate in their crash and incident databases whether window tinting was a factor. Further, even if some levels of window tinting may compromise officer safety, it is possible that some lesser levels of window tinting may not. Despite this lack of empirical evidence, police officers in every state are deeply concerned about aftermarket tinting. Many of them suspect that window tinting is a factor in some traffic crashes; however, their primary concern is with the safety of police officers. Most officers have heard of problems with enforcement, and many of them emphasize the fear of approaching a darkened window that denies them the ability to see the vehicle's occupants.

The majority of states experienced the following problems with collecting data on this issue:

1. Crash reports do not have a place to designate whether any of the vehicles had tinted windows.

2. When window tinting is indicated on the report, the level of tinting is not indicated, and it is difficult to prove that tinting was a factor in the crash or incident.

3. It is difficult to determine the number of vehicles in the state having tinted windows or the number overall that are not in compliance in terms of transmittance. It is especially important to have those figures in order to determine whether vehicles with tinted windows are overrepresented in crashes compared to the general population.

4. Where officer fatalities are involved, the key witness, the officer, is lost.

EXTENT OF WINDOW TINTING IN THE COMMONWEALTH

Table 2 shows the results of a survey of motor vehicle inspection stations conducted in August 1993. At 10 inspection stations in 3 areas of the state, state troopers checked every vehicle for the presence of aftermarket tinting. If the vehicle had window tinting, the amount of light transmitted through the glass was tested. Clearly, there is a great degree of variability in the percentage of vehicles with tinted windows tested in these three areas. The percentage of vehicles with tinted windows ranged from a low of 2.0% in a rural Northern Virginia station to a high of 82.4% at a station on a military base in Tidewater. Because of these widely diverse percentages, it is impractical to attempt to calculate an average level of use for the state. Table 2 shows that most of the vehicles with window tinting were in violation of Virginia law. In fact, 82.2% of the 90 vehicles that were tinted were in violation. The average level of light transmittance on tinted front side windows was 33%, and that for rear side windows was 27%.

Table 2
SURVEY OF VIRGINIA STATE INSPECTION STATIONS

REGION	Number of Vehicles	Number with Tinting	Percentage with Tinting	Percentage in Violation
Northern Virginia				
Metro	94	4	4.3	100
Rural	100	2	2.0	100
Roanoke				
Metro	63	4	6.3	50
Rural	21	1	4.8	0
Tidewater				
Metro	52	27	51.9	93
Rural	50	10	20.0	20
Military	51	42	82.4	93

THE IMPACT OF TINTING ON VEHICLES' INTERIOR TEMPERATURE

About one-half of the energy emanating from the sun is in the form of visible light; slightly less than one-half is infrared radiation; and about 2% is in the form of ultraviolet radiation (Boyd, 1991). As sunlight is transmitted through glass into the interior of a vehicle, a portion of it is transmitted as heat. Some percentage of this heat is absorbed by window glass, and that percentage is transmitted in almost equal parts to the interior and exterior of the vehicle. A very small portion of it moves along the glass by convection (Huber, SAE 885052). This energy can cause heating of the interior to an uncomfortable degree and possibly some damage to the interior, although most interior damage is caused by ultraviolet radiation. It has been estimated that at an outside temperature of 95°F and 60% relative humidity, between 26% and 60% of air conditioner load is attributable to solar energy (Boyd, 1991). The window tinting industry has asserted that one of the benefits of tinting is its ability to screen out portions of sunlight that cause interior heating.

Several studies have tested this assertion. Traditional heat-absorbing tinting is green, metallic brown, or gray and may have more reflective properties than other forms of tinting. These colors in many cases come from iron oxide permeating the glass or the tinting material. Sullivan and Selkowitz (1988) found that some heat-absorbing tinted glass can allow as much as 70% of visible light in while transmitting only 40% of the heat-related solar energy (cited in Boyd, 1991). Hurst and Scroger (1974) examined the impact of tinted, heat-absorbing glass installed in the rear window of a vehicle. They noted that "the climate in the car with the darker glass is nearly perfect, whereas the car with the clear glass is hot." Other studies have produced more measurable results.

Huber (SAE 885052) found that a particular type of heat-absorbing tinting absorbed 50% of the solar energy striking the window, resulting in a 5°F difference between its temperature and that of a vehicle with an untinted rear window. Weigt (1986) found that a vehicle with a heat-absorbing windshield (and with all other windows being tinted) was approximately 2° to 3°C cooler than one without the heat-absorbing windshield when parked, and about 0.5° to 1.5°C cooler when in motion. Results of experimentation in Virginia were similar (Virginia State Police, 1988). Comparing a vehicle without aftermarket tinting to one with 35% light transmittance on the rear side windows and rear window, one with 35% on all windows but the windshield, and one with 20% on all windows except the windshield, the VSP found the tinted vehicles' interiors to be 2° to 4°F lower than those of the untinted vehicle, depending on the time of day. Weigt also found, as would be expected, that the temperature within the car varied with the position of the car by about 1° to 6°C. Differences in dashboard temperature between a vehicle equipped with a heat-absorbing windshield and one without were as high as 16°C. Thus, tinting of windows in such as a way as to make them heat absorbent can reduce the interior temperature of motor vehicles to a certain extent.

MEDICAL CONDITIONS AND WINDOW TINTING

There are two main categories of light-related medical conditions that are relevant to a discussion of window tinting: (1) those that may affect anyone exposed to sunlight, such as skin cancer and (2) those that are the basis for medical exemptions from the usual prohibition against tinting.

The full spectrum of sunlight can be divided into several ranges, each presenting separate health hazards. First, there is the visible range from about 400 to 750 nanometers (nm). This is the range most overtly affected by window tinting. However, also of interest with regard to window tinting are the ultraviolet A (UVA) (220 to 290 nm), the ultraviolet B (UVB) (290 to 320 nm), and the infrared ranges (up to 1,400 nm), which we cannot see, yet each of which is known to cause damage. The transmittance through ordinary glass of wavelengths shorter than 220 nm is generally small. Wavelengths longer than 1400 nm are effectively screened by the atmosphere, and the remainder are blocked out by ordinary glass (Dunn, 1973).

Dangers to the Public Posed by Sunlight

There are a number of ways in which sunlight can adversely affect the human body. Direct and relatively short-term exposure to intense radiation can damage the eye. Long-term overexposure to sunlight can increase the likelihood of skin cancer and cataracts.

Obviously, looking at the sun for extended periods of time, even through glass, can cause serious discomfort and retinal damage. There are three types of possible damage that can result from irradiation of the eye by light waves in the 400 to 1400 nm range (Ham, Mueller, & Sliney, 1976): (1) mechanical damage, which is caused by shock waves resulting from extremely short bursts of radiation that are absorbed in the retinal pigment epithelium; (2) thermal insult, in which long exposure to the wavelengths of light in the 400 to 1400 nm range causes the eye to be heated, thereby causing protein in the eye to coagulate and rendering it opaque to visible light; and (3) actinic insult, which is caused by photochemical effects of extended exposure to short wavelengths of 400 to 550 nm in the visible spectrum with no accompanying thermal changes (Dunn, 1973; Ham et al., 1988).

It is unlikely that any vehicle driver would be exposed to radiation of the type that would cause mechanical damage. With regard to thermal damage, the temperature of the eye would have to be raised approximately 10°C for this to occur (Ham et al., 1976). The eye's discomfort range lies largely in the visible spectrum, but exposure outside the visual range, for example, to infrared radiation, may cause some thermal damage without warning. For instance, the pigment epithelium adjacent to the retina adsorbs wavelengths from 400 to 1,400 nm. Factory glass and aftermarket tinting do not absorb very much infrared radiation. However, it would be extremely unlikely that occupants of a motor vehicle could stare at the sun for the length of time necessary for this kind of thermal damage to occur, although repeatedly looking at a traffic signal close to the sun or driving into the sun could result in some accumulation of infrared radiation.

Although these first two types of damage are extremely unlikely and are not prevented by window tinting, actinic insult is present in a small group of individuals who suffer from actinic reticulosis, which is the basis for one of the medical exemptions.

In addition to these sources of damage, blue light in the 300 to 500 nm portion of the spectrum can lead to conditions resembling senile macular degeneration. The retina is most sensitive to light in this region; thus, extended protection would reduce the occurrence of a number of degenerative disorders.

Although it could be said that any medium that protects individuals from UVA and UVB light while driving would be beneficial, it must be remembered that for most people, the time they spend driving is relatively short compared to their overall daily exposure to sunlight. Without protection during other activities, protection during driving would not have a significant impact on an individual's likelihood of disease. However, for individuals who spend a large proportion of their time driving, protection during driving may improve their chances against disease. Although tinting materials usually have little impact on infrared radiation, plastic materials are effective in blocking ultraviolet light, and tinting materials can be created that will block out at least 97% of the ultraviolet light without giving the plastic a dark color. It is not necessary to reduce visibility to effectively screen out ultraviolet radiation. In fact, ordinary window glass blocks out a significant amount of light, and automotive glass with its typical 82% transmittance blocks out 75% of UV radiation (Boyd, 1991).

Medical Exemptions Based on Photosensitivity

There are a number of conditions under which protection from various regions of the spectrum is prescribed (Virginia State Police, 1988):

1. *Polymorphous light eruption is a catch-all category for all disorders resulting immediately after exposure to sunlight.* Although full-spectrum exposure can cause polymorphous light eruption, the predominant cause is light from the UVB range (290 to 320 nm).

2. *Persistent light sensitivity is a category of disorders in which exposure to a substance or chemical can make an individual sensitive to sunlight for many years.* These individuals cannot tolerate sunlight, particularly UVA or UVB light. They most commonly develop symptoms such as eczema. Another persistent light sensitivity disorder is actinic reticulosis, which is a chronic incurable disease activated by light from the long UV range to visible light. The only treatment is complete avoidance of *all* light.

3. *Porphyrias are disorders in which exposure to light from 400 to 450 nm results in a metabolic defect in the manufacture of heme.*

4. *Solar urticaria is a skin disorder in which hives develop as an allergic reaction to exposure to the sun.* Persons suffering from solar urticaria react to light in the range from 390 to 600 nm. These disorders may last for years; the symptoms may develop within minutes of exposure, or the disorder may enter into remission spontaneously.

5. *Lupus erythematosus is a chronic inflammatory disease of connective tissue that affects the skin and various internal organs.* Lupus erythematosus is not strictly a photosensitive disease. However, light in the UVB range can aggravate the disease.

OPTICAL AND VISUAL ISSUES RELATING TO WINDOW TINTING

Basic Optical Terms

Such terms as *illumination, luminance,* and *contrast* are fundamental to a discussion of any visual process. Among nonspecialists, these terms are sometimes used inconsistently and in a manner that can create confusion in discussions of window tinting.

Target refers to an object that is important for a driver to see. Targets are of two sorts. *Illumination target* refers to a source of illumination, such as a headlight or traffic signal. *Illuminated target* refers to a target that is visible as a result of having been illuminated by some external source such as the sun, street lights, or headlights. *Illumination* refers to the amount of light falling on the target. The range of ambient illumination conditions with which the human visual system can function is quite extraordinary: a bright sunny day provides about 10 million times more light than what is available on a clear starlit night. When a target is illuminated, some of the light is absorbed and some is reflected. The light that is reflected from a target to the eye is called *luminance*; thus, target luminance is a function of two variables: ambient illumination and the proportion of the illumination that the target reflects. In referring to surface color, lightness or darkness depends on the proportion of light that is reflected; light surfaces reflect more light than dark ones.

In order to see a target, it must contrast with its background; it is not sufficient for the target to be illuminated, there must be a sufficient difference between its luminance and the luminance of its background. *Contrast* is defined as the difference between target luminance and that of its background divided by the background luminance. Suppose, for example, that target luminance is 3 fL whereas its background is 2 fL (fL denotes foot Lamberts, a standard measure of light intensity). Contrast in this case is (3 fL – 2 fL) / 2 fL = 1/2. The influence of tinting on the visual and driving performance of drivers is related to contrast; however, not in a manner that can be ascertained without reference to the response characteristics of the human visual system.

The Optics of Window Tinting

The critical term in window tinting is *transmittance*. Transmittance refers to the proportion of light incident upon the window glass that passes through into the air on the other side. Transmittance is a function of two variables: reflection and absorption. *Reflection* refers to the proportion of light incident upon the glass that bounces off of its surface. Smooth and highly polished surfaces such as glass reflect a relatively high proportion of light, and the application of window tinting can increase this proportion. *Absorption* refers to the proportion of unreflected light that fails to pass through the glass as a result of a variety of causes. Transmittance, reflection, and absorption are all expressed as proportions: transmittance = [incident light – (reflected + absorbed light) / incident light] X 100%. In other words, transmittance is equal to the proportion of incident light that is neither reflected nor absorbed.

Federal and state regulations specify that transmittance limits are to be assessed by measuring the passage of light passing at a right angle through a window. This is the most advantageous angle for light transmittance. Reflection and absorption both increase as the angle of incidence deviates from a right angle. A greater proportion of light is reflected as the angle of incidence moves away from perpendicular. Absorption is a function of the distance that the light must pass through the glass, which is minimal when the light strikes at a right angle. Thus, if a window is rated as having a 50% transmittance value, it actually provides the driver with 50% of the incident illumination only when he or she is looking at a target along a line of sight that is perpendicular to the window. Any other viewing angle will cause transmittance to be less than 50%. There is very little reduction in transmittance at viewing angles of less than 20 degrees, whereas angles over 60 degrees result in a substantial decrease in transmittance. Obviously, the severest viewing angles are to be found when a driver looks over his or her shoulder in order to see out of a rear side window.

The reflectance value of a window has a profound impact on the visibility of people and objects viewed from outside of the vehicle. Consider, for example, mirrored sunglasses. It is impossible to see the eyes of someone wearing these glasses because the amount of light reflected off of the surface of the glasses is so much greater than the amount passing through from the wearer's face. Similarly, window tinting films that increase reflectance impede visibility into the vehicle as a result of the increase in the ratio of reflected ambient light to the light passing out from the car's interior. From the driver's perspective, there is no difference between a window with high reflectance versus one that has low reflectance but an equivalent transmittance. A driver is presented with the light transmitted through the window and is unaffected by the sources of the reduction of transmittance: reflection and absorption. On the other hand, someone viewing the interior of a vehicle from the outside is very much affected by the source of transmittance reduction. The greater the reflectance value, the more visibility is impeded. It should be kept in mind that state regulations prohibit the use of window tinting films that have a reflectance value greater than 20%; however, the tint meter provided to police officers is only capable of measuring transmittance.

Finally, it should be noted that transmittance, reflectance and absorption are all expressed as proportions. *Proportions are multiplicative in their influence.* This has three significant implications for issues related to window tinting. First, different transmittance sources combine multiplicatively. So, for example, if a driver looks through a front side window with 50% transmittance at another driver through the other driver's front side window with 50% transmittance, then the luminance available to the first driver is only 12.5% of what it would have been had no transmittance reduction been introduced. This is so because the light striking the observed driver was first reduced by 50% when it passed into the car, it was reduced again when it passed out, and finally it was reduced a third time when it passed through the observing driver's window: 50% x 50% x 50% = 12.5%. (This value is approximate and entails a number of simplifying assumptions.) Furthermore, if the first driver is wearing 50% transmittance sunglasses, then the available luminance is reduced to 6.25%.

The second important thing to bear in mind about the proportional nature of transmittance is that *window tinting films do not reduce contrast.* Since tinting films reduce transmittance proportionally, the target/background contrast is constant across all transmittance levels. Window tinting films impede visual performance by reducing overall luminance, not by reducing contrast. Moreover, these films do not reduce disability glare for the same reason. Glare is the result of very high local contrasts, and contrast is unaffected by window tinting films.

The third issue relates to comparing the effect of different degrees of window tinting. The decrease in the amount of available light that is associated with a comparison of a 100% and a 90% transmittance window is 10%. The decrease associated with a comparison of a 50% and a 40% window is 20%. Obviously, the change from 10% to 0% is a 100% reduction in light. Thus, a reduction in transmittance by some constant value, say 10%, does not result in the same effective reduction in light across the range of transmittance values. A 10% to 0% change is not the same as a 100% to 90% change.

Vision through Tinted Windows

The fundamental constraints on visual performance are expressed by the terms *contrast sensitivity* and *visual acuity. Contrast sensitivity* refers to the amount of contrast needed to detect a target at some level of overall luminance and light adaptation. *Visual acuity* refers to the ability to detect small spacings of contrast such as is required to detect that a small letter is a C and not an O. *Contrast sensitivity and visual acuity improve with overall luminance.* Everyone is aware that they can see better during the day than at night. However, the contrast between a target and its background is unaffected by differences in ambient illumination, such as whether illumination is provided by stars or the sun. The critical variable for human visual performance is overall illumination, and it is a general property of vision that within the range of natural illumination conditions, more illumination results in better visual performance.

Another important property of visual systems is that they adapt to the prevailing level of illumination so as to maximize their contrast sensitivity relative to that level. *Light adaptation* refers to the change in photoreceptor receptivity that occurs when the prevailing level of illumination increases. As our eyes become adapted to a higher level of illumination, it requires more light to produce an equivalent level of receptor activity. Conversely, *dark adaptation* refers to the change in receptivity that occurs when illumination is reduced. Recall the experience of going into a darkened movie theater. At first it is difficult to see your hand in front of your face; however, after about ten minutes you can see your neighboring movie watchers and after half and hour you can see about the theater fairly well. In this case, the receptors responsible for dark vision have increased their receptivity to light. Most light and dark adaptation is accomplished by changes in the photochemicals of the eye's light receptors, not to changes in the size of the pupil as many people suppose. Light adaptation is fairly rapid, whereas dark adaptation is quite slow. It takes about 30 to 40 minutes to completely adapt to the dark. The reason that contrast sensitivity and visual acuity decrease with reduced luminance is that these sensitivities decrease with dark adaptation.

The perceived lightness of a target is a function of contrast, but it is not the same thing as contrast. In order for one target to appear to be twice as bright as another, the luminance of the first target must be 10 times greater than the luminance of the other. *A doubling in perceived brightness requires a tenfold increase in luminance.* This explains why a window tinting film allowing 50% transmittance does not make things look twice as dark. A reduction of transmittance from 100% to 10% would be required to make things appear twice as dark.

Discussions of window tinting often make confusing claims about its effect on glare. Glare is produced by a small area of especially high contrast, such as is produced by headlights at night, or a reflection of the sun off of a high reflectance surface, such as the window of another car. There are two aspects to glare. *Disability glare* refers to the visual masking of a target that is close to a source of glare. A target is much harder to see if it is adjacent to a source of glare. *Discomfort glare* refers to the unpleasant feeling that accompanies exposure to a source of glare. Disability glare is produced by a high contrast and not the absolute luminance of the source of the glare. A headlight viewed during the day does not produce glare as it does at night. Since disability glare is dependent on contrast, it is not affected by window tinting. Discomfort glare is related to absolute luminance and the level of light adaptation. For a given level of light adaptation, the greater the luminance, the greater the discomfort. Thus, the night setting on a rearview mirror does not reduce disability glare; a driver cannot see to the rear better when the mirror is in this position. However, the unpleasant feeling encountered when looking at a source of glare, such as headlights, is reduced by reduced transmittance.

OPTICAL EFFECTS OF WINDOW TINTING ON TRAFFIC AND POLICE OFFICER SAFETY

There are three situations in which the influence of window tinting on performance and safety are at issue: the effects of reduced transmittance on (1) the performance of drivers; (2) facial communication with other drivers, pedestrians, or bicyclists; and (3) the safety of police officers.

The Effect of Window Tinting on the Performance of Drivers

A reduction in transmittance is an impediment to visual performance. Contrast sensitivity and visual acuity improve with increased levels of light adaptation (Van Nes & Bouman, 1967). Since window tinting reduces the overall luminance available to the driver, it hinders visual performance. This conclusion is warranted from what is known about the performance of the visual system. The real issue is whether the reduction in visual performance incurred by the application of window tinting films is sufficiently large to make a difference in driving performance. This is a difficult question to answer; however, the following review provides some evidence that window tinting does have an adverse effect on visual performance as assessed in laboratory and real-world situations.

Haber (1955) performed a theoretical analysis of the loss in contrast sensitivity resulting from tinted glass and the resulting loss in a driver's ability to detect objects with increases in distance. As Dunn (1973) correctly pointed out, this analysis is constrained by the simplifying assumptions and specific parameters employed; thus, it would be inappropriate to draw general conclusions from this analysis other than that distance perception is reduced by the introduction of window tinting. Dunn performed a more general theoretical analysis of the probability of target detection at twilight and at night under varying conditions of contrast and window tinting. He showed how the probability of target detection decreased with reduced contrast and transmittance values. Importantly, he showed that contrast sensitivity decreases at a higher rate for transmittance values below 80%.

The expected deleterious effects of window tinting on visual performance were clearly demonstrated by Wolf, McFarland, and Zigler (1960). These authors performed experiments on the influence of window tinting on five visual functions.

1. *Dark adaptation.* For a given level of dark adaptation, the threshold for detecting light was raised when viewing through tinted glass by an amount corresponding to the reduced transmittance value. In other words, it took 30% more light to see a target through 70% transmittance glass.

2. *Recovery from light "shock."* Following exposure to a bright light, light adaptation levels are raised; thus, light sensitivity is reduced. Viewing the bright light through a tinted filter reduced the loss of light sensitivity; however, this was completely offset by the concomitant reduction in target luminance. Thus, window tinting had no effect on recovery from exposure to a sudden bright light.

3. *Visual acuity.* Visual acuity was reduced for targets viewed through tinted filters. Transmittance values used in this study ranged from 65% to 72%. The visual test required observers to detect the location of a gap in C-shaped figures of various sizes. It was found that the filters reduced visual acuity to such an extent that the targets needed to be 10% to 20% larger to be detected.

4. *Depth perception.* Stereo depth perception is influenced by overall luminance, and depth perception was reduced by 25% to 30% when filters were used to reduce transmittance to between 65% and 72%.

5. *Vision in the context of glare.* Visual acuity was assessed in the context of a source of glare. Glare reduced visual acuity equally with or without the presence of a tinted filter. As discussed earlier, disability glare is a function of contrast, which is unaffected by decreased transmittance.

McFarland, Domey, Warren, and Ward (1960) investigated dark adaptation as a function of age and tinted filters. It is well known that dark adaptation becomes increasingly less effective with age. For example, after 30 minutes of dark adaptation, it takes more than 10 times as much luminance for an average 70-year-old to detect a target compared to an average 20-year-old. McFarland et al. showed that the threshold for detecting light increased when viewing occurred through tinted filters for subjects of all ages. Elderly individuals already have poor night vision, and tinted windows introduce an additional impediment.

Both the theoretical analyses and the empirical demonstrations support an indisputable conclusion: *Window tinting is an impediment to visual performance when targets are near threshold without the presence of the filters.* However, the question remains: What is the likelihood that a driver will encounter such conditions? This question has motivated a number of studies on the effects of window tinting in situations more representative of those encountered in everyday driving.

The initial studies on window tinting and driving were directed at the effect of newly introduced windshield tints that could result in transmittance values as low as 70%. Heath and Finch (1953) assessed viewing distances at which targets were detected at night by drivers in cars with 89% and 71% transmittance. Given the 45° angle of the windshield, the effective transmittance values were 86% and 69%, respectively; thus, there was a 20% difference in transmittance. The testing occurred at night with headlight illumination. A variety of targets were placed on a new road that had not yet been opened to the public. It was found that targets needed to be about 15 ft closer, on average, before they were detected. Subject variability was high. Roper (1953) conducted a similar study at night on an airstrip. His two cars were equipped with windshields differing in transmittance by 18%, and he tested target detection under driving conditions with and without a source of glare, which was provided by the headlights of an oncoming car. Relative to the tinting manipulation, he found a 6% reduction in viewing distance without glare and a 2% reduction with glare. In the presence of glare, there was no difference in performance over the last 500 ft. Doane and Rassweiler (1955) replicated Roper's design using targets that were harder to detect. They found that standard heat-absorbing windshields reduced detection distance by about 3%, a result similar to Roper's. Dunn (1973) used a stationary vehicle cab testing device that was placed on a private road. Targets were near threshold, and their detection distance was assessed at night with headlamp illumination. Two windshields were employed: one clear (96% transmittance) and one tinted (78% transmittance). Viewing distances were found to be greater by fewer than 15 ft with the clear glass. As with the previous studies, variability among the subjects was very high.

These studies suggest that there is a small detrimental effect for tinting windshields to a transmittance level between 70% and 90%. This impediment has only been demonstrated at night and for targets that are difficult to see. Even under these less than optimal viewing conditions, the effects of this level of tinting are small.

The most relevant study for the purpose of assessing the influence of window tinting below transmittance levels of 70% was conducted by Rompe and Engel (1987). They used a driving simulator that was equipped with interchangeable windshields having transmittance values of 89.0%, 76.4%, 58.0%, and 40.0%. Following a 20-min learning phase, subjects drove the simulator over a projected road for 12 min. During this test phase, single square targets appeared for 2 sec at one of two randomly selected locations along the horizon. There were a total of 50 targets, and each had an opening on 1 of its 4 sides. Targets were presented at 4 different contrast levels. Background luminance simulated twilight driving conditions. There were 2 groups of subjects: 1 group wore spectacles and 1 did not. The subjects' task was to indicate the location—left/right or up/down—of the opening as fast as they could. The dependent measures consisted of both the percentage of correct detections of the target's opening and the reaction time. This study also included a condition in which a source of glare was present.

The essential results of this study are as follows: For the normal sighted subjects, the percentage of correct detections was near 100% for the 3 groups of targets with the highest contrast at all levels of window tinting. For the targets with the lowest contrast, 80% percent of the attempted detections were correct for the windshields with 89%, 76%, and 58% transmittance but dropped to below 60% for the windshield with 40% transmittance. The spectacle wearers were also unaffected by the level of transmittance for the three groups of targets with the highest contrast; however, for the targets with the lowest contrast, they exhibited a decline in correct detections for both the 58% and 40% windshields. For spectacle wearers, detection rates for the windshield with 40% transmittance were below 40% in the condition of lowest contrast. Target contrast had an effect on reaction time, but transmittance level did not. The presence of glare yielded a similar pattern of results. Normal sighted subjects were unaffected by transmittance level except at the 40% level, at which the detection rate dropped significantly. Spectacle wearers showed a steady decline in detection rate at each reduction in transmittance. There was no evidence that windshields with low transmittance reduced the influence of disability glare. *This study clearly shows a reduction in low-contrast target detection at low levels of transmittance for normal sighted people and a pervasive and increasing reduction in visual performance for spectacle wearers at levels below 70%.* Boyd (1991) noted that both Volkswagen and Flachglas AG used this study as the basis for advocating a minimal transmittance level of 70% to 75% for the forward 180° field of view.

Although the results of this study provide evidence of the detrimental effects of window tinting on dusk and night driving, it is likely that the effects of tinting were underestimated. This is true for at least two reasons. First, the simulator situation presented an exceedingly simple and well learned task. The driving scene was void of other traffic, and all the driver needed to do was keep the car on the roadway at a comfortable speed. The targets appeared in only two locations, and they were well known to the subjects, who had 20 minutes of training prior to the testing. This situation is far less demanding than the detection of unanticipated targets in a situation requiring a heavy workload from the driver.

The second issue relates to light adaptation. In the Rompe and Engel study, tinting was applied to the windshield, and the simulated driving scene was seen only through this forward window. Because the windshield cannot be tinted in Virginia, drivers spend most of their time looking through a windshield with 80% transmittance, but must detect targets through a front side window that may have a maximum transmittance of 50%. Since a driver's light adaptation level will be adjusted to the luminance passing through the windshield, he or she will be less sensitive to the luminance level afforded by the reduced transmittance of the front side window. Thus, visual performance is not only impeded by the 38% reduction in luminance between the windshield and the front windows, it is also adversely affected by the higher level of light adaptation maintained by prolonged viewing through the windshield with its transmittance of 80%.

The IIT Research Institute conducted a study sponsored by the tint manufacturing industry that assessed the reaction time required to detect high-contrast targets with varying levels of window tinting at different times of day (Wakeley, 1998). The effects of window tinting on reaction time were quite minimal. Even though no statistical evidence was provided to support this conclusion, Wakeley also concluded that the 50% film yielded better response times than the 70% film. Not only is this conclusion unsupported by statistical analyses, it makes no theoretical sense. The detection of high-contrast targets should be unaffected by window tinting, and an examination of the figures provided in the report confirmed this.

The study was also run with a glare manipulation in which a source of glare was presented next to the target. Since the target was always present, the subjects knew that it was next to the source of glare; however, they were asked to report on whether or not they could see it. It was found that reports of failure to see the target were reduced with increases in tinting. This study is suspect for a number of reasons. First, the subjects were being asked to report on whether they could see a target that they knew was there. This is not an adequate experimental design to assess detectability. For a given level of light adaptation, discomfort glare is related to absolute luminance; thus, the subjects may have been more willing to look for the target when luminance was reduced by the tinting films. The studies by Wolf, McFarland, and Zigler (1960) and Rompe and Engel (1987) clearly show that tinted filters cannot improve acuity in the presence of glare. Wakeley (1988) critiqued the study by Wolf, McFarland, and Zigler and, in so doing, gave evidence of being confused about what glare is and how it is affected by window tinting. Regarding glare, Boyd (1991) points out that since a source of glare only impedes contrast sensitivity for adjacent targets, tinted front side windows will have no effect on the detection of targets viewed through the windshield.

The focus of all of these studies has been primarily on the influence of window tinting on driving in a forward direction. One study, conducted by Freedman, Zador, and Staplin (1991) for the Insurance Institute for Highway Safety, investigated the effect of window tinting on detecting objects while backing a vehicle. Four levels of window tinting were applied to the rear side and rear windows of a laboratory vehicle: 69%, 53%, 36%, and 22%. Three 6- by 9-ft projection screens were placed behind the vehicle. Natural scenes were projected on these screens at a size appropriate for the viewing distance. One of five targets was present on some of the trials. The targets were a vehicle, a cyclist, a pedestrian, a child, and road debris. These targets differed in their size and contrast levels. The subject was given 10 seconds on each trial to determine whether one of the targets was present. Subjects ranged in age from 18 to 90 years of age. The vehicle was always detected. The probability of detecting the child and the debris decreased with reduced transmittance values. The probability of detection also decreased with the subject's age. The authors of this study conclude that this study likely understates the magnitude of the visibility deficits that are caused by high levels of window tinting. This is so because the subjects were not actually driving the vehicle; thus, they had no distractions during the full 10 seconds that they had to respond.

The Effect of Window Tinting on Facial Communication

In many situations, drivers, pedestrians, or bicyclists will attempt to ascertain the intentions of a motorist by looking at his or her face. For example, when two cars are stopped at an intersection, it is desirable for the drivers to make eye contact in order to determine who will yield the right of way. Similarly, pedestrians or bicyclists want to observe where a driver is looking in order to assure themselves that the driver sees them.

There are no studies on the effects of window tinting on observing a driver's face in such situations. Studies have examined the effects of window tinting on a police officer's ability to detect the contents of a vehicle when approaching a car that has been pulled over. These studies do not generalize well to facial communication for a number of reasons. First, drivers may be viewing each other through front side windows that have been tinted in both cars. All of the existing research has examined viewing through a single tinted window. Second, the viewing distance at which experimental observers inspected the interior of automobiles was far smaller than that typically encountered in driving situations in which drivers, pedestrians, or bicyclists seek to discern the intentions of a driver by looking at his or her face. Finally, it is likely that the time allowed for interior car inspection was far greater than what is afforded to someone seeking to discern the intentions of a motorist by looking at his or her face. Since this situation has not been investigated directly, only an analysis of the relevant optical and visual issues can be presented here.

A critical optical variable with facial communications is *reflection*. When looking through glass, the luminance presented to the eye has two sources. One is the light transmitted through the window from the other side and the other is the light reflected off of the exterior of the window. *The reflected light masks the transmitted light in proportion to the ratio of reflected to transmitted light.* Imagine sitting in a living room that is illuminated by a table lamp. In this situation, one can look out of a window during the day and see what is going on outside without any difficulty. At night, however, the window functions like a mirror, and all that can be seen are reflections from the inside. The amount of interior light reflected off of the window is the same at both of these times. The increased visibility of reflections at night is the result of the ratio of reflected to transmitted light. During the day, the transmitted light is much greater than that reflected, whereas at night, the reflected light is far greater than that transmitted.

Window tinting reduces the amount of light emanating from the interior of a vehicle while increasing the proportion of light reflected off of its surface from the outside. Both of these effects—the loss of light emanating from the vehicle's interior and the increase in reflections from the outside—reduce the visibility of the interior; moreover, these effects combine in the ratio of reflected to transmitted light to further reduce visibility.

The reduction in light emanating from the interior of a vehicle is affected *twice* by the transmittance values of its windows. Thus, if a window has a transmittance value of 50%, then the light passing through and illuminating the vehicle's interior is reduced by half, and that reflected back out of the window is again reduced by half. In other words, *the light available to someone looking into a vehicle is reduced by the square of the transmittance value of its windows.* (This generalization assumes that the effective illumination is falling equally on all windows.) Consider the case of two drivers attempting to make eye contact through front side windows with a transmittance of 50%. The light illuminating each driver is reduced by 50% as it passes into their cars, by 50% again as it passes out, and by an additional 50% as it is transmitted into the other driver's vehicle. Thus, the available luminance is 12.5% of what would have been present without any reduction in transmittance. If both drivers had windows with a transmittance of 70%, then luminance would be reduced to 34.3%, which is 2.74 times greater than the amount of light available with windows with a transmittance of 50%. In this case, a 20% difference in window transmittance results in almost a three-fold difference in effective luminance.

Window tinting films reduce transmittance, in part, by increasing reflectance. At present, only transmittance levels can be assessed without reference to allowable levels of reflectance. The only device found for measuring light reflectance is currently marketed only in Japan by Suga Test Instruments Co., Ltd. Although available tinting films increase reflectance, it is not known to the authors what the reflectance magnitude range is for these films. Boyd (1991) reports a 1990 automotive window light transmittance survey; however, no reflectance values were provided.

The magnitude of reflected light depends not only on the magnitude of ambient illumination, but also on the orientations of observers and sources of luminance to the reflecting surface. So, for example, the sun's position may be such that its image is reflected off of the windows on one side of a car but not off of those on the other side. Whether this reflection is a liability to an observer would depend on where he or she is located with respect to the car. The most intense sources of ambient illumination are typically the sun and sky. For this reason, reflections are particularly troublesome during the day.

Since, by definition, reflected light is not transmitted through a window, *the driver has no way of knowing what his or her window looks like from the outside.* This is analogous to the situation of someone wearing mirrored sunglasses. The wearer does not see the reflections that prevent everyone else from seeing his or her eyes. Likewise, a driver who can see the face of another motorist, pedestrian, or bicyclist well may not realize that his or her own face is masked to others by reflections. Thus, reflections create uncertainties for all parties. The pedestrian, for example, does not know whether he or she is seen by the driver when the motorist's face is masked by a reflection. The motorist, on the other hand, cannot tell whether his or her own face is visible to the pedestrian.

Since window tinting both reduces the light emanating from a vehicle's interior and increases the reflectance value of its windows', the ratio of reflected to emanating light increases. It is this ratio that affects one's ability to see a motorist's face during the day. The luminance transmitted from the motorist's face to another observer may be more than sufficient for visual communication; however, if the ratio of reflected to transmitted light is too great, then the motorist's face will be masked by the reflection. The occurrence of masking reflections depends on the orientation of sources of bright luminance and the orientation of the observer to the window being observed.

The Effect of Window Tinting on the Safety of Police Officers

Finally, there is a concern about the safety of police officers who must approach a stopped vehicle that has tinted windows. The State of Virginia permits the application of tinting films that reduce transmittance to 35% on the rear and rear side windows. This tinting may impede an officer's ability to detect weapons, contraband, or threatening acts by the driver or passengers. This concern has motivated a number of studies; however, all of them have yielded equivocal results.

The optical and visual issues applicable to this situation are essentially the same as those reviewed above in the discussion of facial communication. The application of window tinting reduces the luminance of a vehicle's contents by the square of the window's transmittance value, increases external reflections, and increases the likelihood that reflections will interfere with seeing into a car.

Three studies and one demonstration investigated the influence of tinting on identifying objects within a parked car. One study was sponsored by tint film manufacturers, and the others were conducted by police departments. The former found no detrimental effects of window tinting even for tinting films having transmittance values as low as 20%. On the other hand, the police studies found that window tinting greatly reduced the ability of officers to identify objects inside experimental cars. These conflicting results are likely the result of differences in the designs of the studies. More important, all of the studies suffer from serious design flaws that make any generalizations difficult to draw.

The IIT Research Institute conducted a study designed to determine whether the presence of window tinting films affected an observer's ability to detect various articles of contraband, weapons, and movements of the vehicle's occupants (IIT, 1990). The tinting films had a transmittance between 20% and 50% and were applied to rear and rear side windows with a transmittance of 70%. Testing occurred during the day, at dusk, and at night. The results showed no effect for the presence of any of the tinting films.

The most obvious problem with the study was that the recognition rates under all tinting conditions were rarely below 95%, and on the few occasions when they were below 90%, variability was very high. In other words, the task of identifying the objects and events within the cars was so easy in all conditions that tinting had no effect. The IIT report does not mention what the viewing distances were nor how much time the observers had to make their judgments. It may be that the IIT study is valid and that identifying the contents of a car through tinted windows under varying conditions of ambient illumination is such an easy task that tinting does not interfere with performance. On the other hand, it may be that the viewing distance or inspection times were not within the range afforded to police officers in typical situations. Of this study, Boyd (1991, p. 24) wrote: "Some of the findings seem to violate principles of visual detection. For example, the ambient light level had no effect on target recognition; window transmittance had no effect on target recognition and the lowest recognition scores obtained under nighttime conditions were with the 70 percent transmittance glazing."

The Virginia State Police conducted a study on the identification of vehicle contents using varying tinting values and ambient illumination conditions (Virginia State Police, 1988). They employed four cars with the following levels of tinted windows: (1) no tinting, (2) 35% rear side windows and rear window tinting, (3) 35% tinting on all windows except the windshield, and (4) 20% tinting applied to all windows except the windshield. They found a dramatic effect for window tinting. For example, the percentage of police officers who failed to identify 50% or more of the articles in the vehicles was as follows for the four cars, respectively: 19%, 59%, 65%, and 95%. The problem with this study's design is that all officers made inspections of all four cars in the same order from most tinting to least. This testing order was likely motivated by the desire not to give the officers too much experience with the items that would be present. An item seen in the untinted car would subsequently be easier to identify in the reduced viewing conditions of the heavily tinted car. However, the order effect problem is also applicable to the most-to-least tinting order. That is, the improved performance found with a reduction in tinting may be the result of the increased familiarity that the officers obtained with each testing situation. The car with the most heavily tinted windows may have yielded the lowest detection rates because the officers always examined it first, at which time they were unfamiliar with the items to be identified.

The New York State Police conducted a similar study and found a similar impairment of performance with the reduction of transmittance in window tinting (N.Y. State Police, 1992). As with the Virginia State Police study, the design employed is fundamentally flawed by the use of a single testing order (most to least tinting). Again, improved performance with the reduction in tinting is confounded with the observers' increasing familiarity with the objects to be identified.

Finally, Boyd (1991) reported on a demonstration performed by the Maine State Police for members of the state legislature. Legislators were asked to approach a car with 35% tinting film applied to the rear and rear side windows. In the back seat of the car was a man with a drawn gun. None of the lawmakers noticed the gun. The demonstration was then repeated using a car with windows with 50% tinting film applied. In this case all of the observers reported adequate visibility. Once again, testing order was confounded with the degree of tinting, and no definitive conclusions are warranted.

These studies commented very little on the influence of reflectance on one's ability to see into a vehicle that has been heavily tinted. For a vehicle having 35% transmittance in the rear and rear side windows, effective luminance for interior targets has been reduced to 12.25%. Part of the decrease in transmittance has been achieved through an increase in reflectance. Given this decrease in target luminance and the concomitant increase in external reflected light, the likelihood that reflections will mask a target is high. It must be kept in mind, however, that reflectance masking depends on the orientation of the sources of luminance and the observer to the window. For example, an observer may be able to see adequately into one rear side window but be unable to see anything but the sun's reflection when looking at the other. Thus, empirical research cannot be expected to specify the degree to which a particular transmittance value will impede visual inspection of a vehicle's interior. The disruptive effects of reflections are situationally specific. At best, empirical studies can demonstrate the range of effects that can be expected under a variety of illumination conditions.

Observations Comparing Vehicles with Tinted and Untinted Windows

As part of this study, two identical vehicles (Chevrolet Caprices), one tinted to the legal maximum and one with no aftermarket tinting, were driven by the principal author. Observations were made concerning the tinting, its application, and any optical changes it created. These observations appear in Appendix B.

SUMMARY OF FINDINGS

Federal and State Laws

- The only federal restriction on the aftermarket tinting of motor vehicle glass is that the tinting film may not be applied by a car dealer, manufacturer, or by an automobile repair shop.

- There is no typical pattern that characterizes the various state laws on window tinting. Virginia's new laws on minimum levels of light transmittance are more restrictive than the laws of 27 states and less restrictive than the laws of 8 others, with the remaining 14 states having greater restrictions on some windows and less on others.

- The 1993 changes in Virginia's window tinting laws have facilitated enforcement by authorizing the Division of Purchases and Supply to establish standards for equipment to measure light transmittance, which makes possible the use of a meter to test light transmittance.

- A survey of 10 state motor vehicle inspection stations revealed that over 80% of the surveyed vehicles that had aftermarket window tinting were in violation of Virginia's new law.

Issues Related to Light Transmittance

- Window tinting reduces the ability to detect targets that would be difficult to see through clear glass.

- Reduced light transmittance resulting from window tinting can be a liability when ambient lighting is low.

- The adverse effects of window tinting become increasingly pronounced as transmittance goes below 70%, particularly for people who wear spectacles and for older drivers.

- There is no evidence, however, that reduced visibility is of any significant consequence to the performance of drivers during well-illuminated, daytime hours.

Issues Related to Light Reflectance

- A critical optical variable in seeing into a vehicle is reflectance. Reflected light masks the transmitted light in proportion to the ratio of reflected to transmitted light. Thus, window tinting reduces the amount of light emanating from the interior of a vehicle while increasing the proportion of light reflected off of its surface from the outside.

- The only device found for measuring light reflectance is currently marketed only in Japan.

Other Optical Issues

- Window tinting can reduce discomfort glare, which is the unpleasant feeling that accompanies exposure to a source of glare.
- Window tinting films do not reduce contrast, which is the difference between a target's luminance and the luminance of its background divided by the background luminance. Since window tinting films reduce transmittance proportionately, the target/background contrast is constant across all transmittance levels.

Effects on Traffic and Police Officer Safety

- Although there are only limited optical benefits from window tinting and there are a number of potential optical detriments, there is no empirical evidence to indicate that the tinting allowed under Virginia's current laws creates a safety hazard in terms of the performance of drivers.
- There are numerous flaws in previous empirical research on the effects that window tinting may have on a police officer's ability to see into a vehicle. There is no conclusive evidence on this issue.
- There are presently no studies adequately dealing with the impact of window tinting on eye contact with drivers in vehicles with tinted windows.

CONCLUSIONS

1. Although there are reasons to suspect that there are some conditions under which tinted windows would compromise safe driving, there is insufficient evidence to back these suspicions. Optical studies indicate that window tinting will affect all aspects of visibility except contrast and disability glare, and some empirical studies conducted in a laboratory setting indicate tinting does adversely affect visibility. However, although this adverse effect has been documented using driving simulators, it has not been documented in driving on the road. Also, even though an adverse effect on visibility has been demonstrated,

it has yet to be shown exactly which elements in the visual field will be affected and how that would affect driving. Further, there is insufficient evidence to indicate whether there is a point at which tinting provides too little light transmittance for safe driving.

2. Although there is some anecdotal evidence that the safety of police officers may be compromised by the use of window tinting, there is little documentation to support this. Previously conducted studies on visibility into motor vehicle interiors are methodologically flawed and provide conflicting results.

3. Although there is optical evidence that window tinting would adversely affect the ability of pedestrians, bicyclists, and drivers to make eye contact, no research has been conducted on this topic.

4. Reflectance seems to have the potential to adversely affect drivers' visibility as well as prevent eye contact. However, the adverse effects of reflections are situationally specific. Although there are restrictions on reflectance in Virginia's window tinting statute, there are no reflectance meters commonly used in the United States available for use in enforcement.

RECOMMENDATIONS

1. It is recommended that Virginia's new law on window tinting not be changed. There is no empirical evidence that the new standard compromises safety; thus, no change is warranted unless compelling evidence that the standards compromise safety is found in the future.

2. Federal regulations and/or action by the states should be encouraged to foster uniformity in aftermarket window tinting laws and regulations. Such action would remove the burden of changing window tinting applications by military and other individuals who relocate from one state to another.

3. Future studies on the effect of window tinting on facial communication should manipulate reflectance as well as transmittance values.

4. A device should be acquired to measure light reflectance. The current maximum of 20% reflectance is very difficult to enforce, since the police have no available means for measuring reflectance. Police officers should be equipped with the means to assess reflectance as well as transmittance values.

5. Future research should investigate the effect of window tinting on the performance of drivers. A substantial amount of research has been directed at the question of whether a driver's performance is adversely affected by window

tinting. From a survey of this research, it can be concluded that visual performance is impeded by tinted windows when the targets to be detected are already near the detection threshold without window tinting. That is, low contrast targets that are difficult to detect through untinted glazing at dusk, dawn, or at night will be harder to see or be undetectable when viewed through tinted windows. It would be desirable to conduct additional research to directly examine the implications of window tinting in situations such as looking to the rear when merging into traffic or changing lanes.

The greatest difficulty in designing such a study is to define an experimental situation that generalizes to actual driving conditions. Except for the Freedman, Zador, and Staplin (1991) study on backing, most of the previous studies have investigated the effect of tinting the windshield but not the rear and rear side windows. Moreover, all but one of these studies looked at windshield transmittance values of about 70% and above. Rompe and Engel (1987) employed lower transmittance values; however, it is impossible to know whether their simulator situation presented conditions that would generalize to actual driving situations. The targets in this study were geometric shapes located in only two forward locations. Wakeley (1988) investigated a 360 degree view; however, as was discussed above, little can be concluded from this study.

The ideal study design would involve an actual situation in which drivers and/or passengers would be required to detect targets to the side or rear of their moving vehicle. Such a situation was used by Allen (1979) in studying the influence of tinted and photochromatic prescription spectacles. In Allen's study, drivers drove a 58-mile course on actual highways and were required to detect white stripes that had been painted to the side of the roadways. A similar study on the effects of window tinting could be designed in which drivers and/or passengers were required to detect targets that could only be seen out of side and rear windows. It would be essential that discrimination times and targets be comparable to those encountered in the relevant situations of merging and changing lanes.

6. Future studies should investigate the effect of window tinting on facial communication. Visual communication between drivers, pedestrians, and bicyclists is essential to safe driving, and there is no research directly bearing on this issue. For a number of reasons, the studies on observing items within a car by a person standing close by do not generalize well to the driver communication situation for three reasons. First, drivers may be viewing each other through front side windows that have been tinted in both cars. Second, the viewing distance at which observers inspected the interior of automobiles was far smaller than that typically encountered in driving situations in which drivers seek to discern the intentions of other drivers by looking at their faces. Finally, no analyses of the appropriate viewing times have been done, and it is likely that the time allowed for interior car inspection was far greater than what is afforded to a driver seeking to make eye contact with another motorist.

Clearly, research should be conducted to investigate a driver's ability to observe another motorist's face when one or both windows have been tinted to varying degrees and when ambient illumination conditions have been varied. An additional study should ascertain the effects of tinted windows on facial communication between a motorist and pedestrians.

The design of such studies would be fairly easy to implement. A number of stationary vehicles that have been tinted to varying degrees could be viewed from an appropriate distance. Under realistic time limitations, an observer would be required to determine the direction of gaze of a driver seated in the car. The observer might either be seated in another parked car or be standing outside. Tint transmittance levels, orientation with respect to the sun or other high illumination reflection sources, and time of day would need to be varied.

7. Future studies should investigate the effect of window tinting on the safety of police officers. The 35% light transmittance tinting that is allowed for the rear and rear side windows may impede an officer's ability to detect weapons, contraband, or threatening acts by the driver or passengers. This concern has motivated a number of studies; however, all yielded equivocal results for reasons that were discussed earlier in this report. This is an area in which additional research is urgently needed; therefore, the authors recommend that the following research be undertaken.

The basic design of Virginia and New York State Police studies will be replicated with the exception that a between-subjects design will be employed. This means that each observer will see only one car and that the rate of content identification will be assessed by looking at the performance of different groups of individuals, each group looking at a different car having different tinting values.

The first step in the study will be to consult with the State Police on their procedures for approaching cars that they have pulled over. Viewing distance and duration will be in accordance with VSP procedures.

Four experimental cars will be employed having the following tinting film values: (1) no tinting, (2) 50% applied to all windows except the windshield, (3) 50% applied to the front side windows and 35% to the rear and rear side windows, and (4) 35% applied to the front side windows and 20% to the rear and rear side windows.

Each car will be observed at three times of day: mid-day, dusk, and night. Mid-day viewing tests will be made only on sunny days. In addition, each car will be approached from the rear on either the driver's or passenger's side. This manipulation is included since, depending on the location of sources of high illumination reflection, the windows on one side of the car may be far easier to see into than those on the other side.

Two hundred and forty observers will be tested: 10 observers x 4 cars x 3 times of day x 2 viewing locations. The cars will be parked on the grounds of the University of Virginia near well-traveled walkways. Passersby will be asked to participate in a quick experiment on visual perception. If they agree to participate, they will be asked to provide information on their visual acuity and what their corrected vision is if they wear spectacles. Each participant will be asked to stand at a predetermined location and to look into the rear side window of one of the experimental cars and to identify all of the items that are there. Items will range in size and reflectance. Once the observers have completed this task, they will be asked to approach the car until they can clearly see and identify all of the items therein. This distance will be recorded. Analyses will examine the percentage of items identified on the first test and the viewing distance selected on the second.

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APPENDIX A

LEGISLATIVE ACTION CONCERNING
MOTOR VEHICLE WINDOW TINTING
BY THE 1993 VIRGINIA GENERAL ASSEMBLY

1993 SESSION

LD9411749

SENATE JOINT RESOLUTION NO. 293

AMENDMENT IN THE NATURE OF A SUBSTITUTE

(Proposed by the House Committee on Rules

on February 19, 1993)

(Patron Prior to Substitute—Senator Waddell)

Requesting the Departments of Motor Vehicles and State Police to study tinted motor vehicle glass.

WHEREAS, motor vehicles equipped with colored or tinted windows and windshields are appearing in ever-increasing numbers on the highways of Virginia; and

WHEREAS, some of the colored window glass is installed as original equipment and some is the result of various aftermarket applications; and

WHEREAS, the Code of Virginia establishes strict standards for the installation and use of window tinting films in motor vehicles; and

WHEREAS, these are among the strictest state standards of their kind in the United States; and

WHEREAS, there are, on the one hand, increasing complaints that Virginia's standards are overly strict; and

WHEREAS, there are, on the other hand, increasing complaints that existing standards are unevenly and ineffectively enforced; and

WHEREAS, it is highly desirable that the needs of motorists with medical conditions that require their being protected from intense sunlight be accommodated and that the rights of individuals to configure their motor vehicles as they see fit be recognized, so long as in so doing they do not endanger their own safety or the safety of others on the highways; and

WHEREAS, it is equally desirable that, in the interests of safety, motorists be able to make eye contact with one another and law-enforcement officers be able to observe motor vehicle occupants; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Departments of Motor Vehicles and State Police be requested to study tinted motor vehicle glass and tinting films applied to motor vehicle glass. The Departments shall examine Virginia's laws relating to tinted motor vehicle glass and related subjects and the enforcement of these laws, and make such legislative and other recommendations as may be appropriate.

The Departments shall complete their work in time to submit their findings and recommendations to the Governor and the 1994 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for processing legislative documents.

Official Use By Clerks

Agreed to By The Senate		Agreed to By The House of Delegates	
without amendment	☐	without amendment	☐
with amendment	☐	with amendment	☐
substitute	☐	substitute	☐
substitute w/amdt	☐	substitute w/amdt	☐
Date: ______		Date: ______	
Clerk of the Senate		Clerk of the House of Delegates	

1993 SESSION

VIRGINIA ACTS OF ASSEMBLY – CHAPTER 300

An Act to amend and reenact § 46.2-1053 of the Code of Virginia, relating to sun-shading or tinting films on motor vehicles.

[H 1436]

Approved MAR 2 8 1993

Be it enacted by the General Assembly of Virginia:
1. That § 46.2-1053 of the Code of Virginia is amended and reenacted as follows:

§ 46.2-1053. Equipping certain motor vehicles with sun-shading or tinting films or applications.—Notwithstanding the provisions of § 46.2-1052, a motor vehicle operated by or regularly used to transport any person with a medical condition which renders him susceptible to harm or injury from exposure to sunlight or bright artificial light may be equipped, on its windshield and any or all of its windows, with sun-shading or tinting films or applications which *reduce the transmission of light into the vehicle to levels not less than 35 percent and either (i)* are ~~of a type~~ approved by the Superintendent of State Police ~~and which reduce the transmission of light into the vehicle~~ *or (ii) have been installed in another state and have a minimum light transmittance of 70 percent on the windshield and 35 percent on other windows* . Vehicles equipped with such sun-shading or tinting films shall not be operated on any highway unless, while being so operated, the driver or an occupant of the vehicle has in his possession a certificate issued by the Superintendent of State Police authorizing such operation. The Superintendent shall issue such certificate only upon receipt of a signed statement from a licensed physician or licensed optometrist (i) identifying with reasonable specificity the person seeking the certificate and (ii) stating that, in the physician's or optometrist's professional opinion, the equipping of a vehicle with sun-shading or tinting films or applications is necessary to safeguard the health of the person seeking the certificate. Certificates issued by the Superintendent under this section shall be valid so long as the condition requiring the use of sun-shading or tinting films or applications persists or until the vehicle is sold, whichever first occurs. Such certificates shall permit the approval of any such vehicle upon its safety inspection as required by this chapter if such vehicle otherwise qualifies for inspection approval. In the discretion of the Superintendent, one or more certificates may be issued to an individual or a family. *The Division of Purchases and Supply, pursuant to § 2.1-446, shall determine the proper standards for equipment or devices used to measure light transmittance through windows of motor vehicles. Law-enforcement officers shall use only such equipment or devices to measure light transmittance through windows that meet the standards established by the Division. Such measurements made by law-enforcement officers shall be given a tolerance of minus seven percentage points.*

President of the Senate

Speaker of the House of Delegates

Approved:

Governor

1993 SESSION

VIRGINIA ACTS OF ASSEMBLY – CHAPTER 808

An Act to amend and reenact §§ 46.2-1052 and 46.2-1053 of the Code of Virginia, relating to signs, decals, stickers, sun-shading materials, and window tinting on motor vehicle windshields and windows; penalty.

[H 1990]

Approved MAR 28 1993

Be it enacted by the General Assembly of Virginia:
1. That §§ 46.2-1052 and 46.2-1053 of the Code of Virginia are amended and reenacted as follows:

§ 46.2-1052. Signs, decals, and stickers on windshields, etc.; penalties.—A. Except as otherwise provided in this article or permitted by federal law, it shall be unlawful for any person to operate any motor vehicle on a highway with any sign, poster, colored or tinted film, sunshading material, or other colored material on the windshield, front or rear side windows, or rear windows of such motor vehicle. This provision, however, shall not apply to any certificate or other paper required by law or permitted by the Superintendent to be placed on a motor vehicle's windshield or window.

The size of stickers or decals used by counties, cities, and towns in lieu of license plates shall be in compliance with regulations promulgated by the Superintendent. At the option of the motor vehicle's owner, such stickers shall be affixed either at the upper edge of the center of the windshield or at some other place which may be designated by the Superintendent.

B. ~~Except as provided in § 46.2-1053, but~~ Notwithstanding the foregoing provisions of this section, whenever a motor vehicle is equipped with a mirror on each side of such vehicle, so located as to reflect to the driver of such vehicle a view of the highway for at least 200 feet to the rear of such vehicle, any or all of the following shall be lawful:

1. To drive a motor vehicle equipped with one optically grooved clear plastic right-angle rear view lens attached to one rear window of such motor vehicle, not exceeding eighteen inches in diameter in the case of a circular lens or not exceeding eleven inches by fourteen inches in the case of a rectangular lens, which enables the driver of the motor vehicle to view below the line of sight as viewed through the rear window;

2. To have affixed to the rear side windows, rear window or windows of a motor vehicle any sticker or stickers, regardless of size; *or*

~~3. To have affixed to the rear side windows, rear window or windows of a motor vehicle a single layer of any sun-shading material of a type that has been approved by the Superintendent of State Police and has a luminous transmittance of at least thirty-five percent;~~

~~4. To affix to the front side windows of a motor vehicle a single layer of any sun-shading material of a type that has been approved by the Superintendent and has a luminous transmittance of at least seventy percent; or~~

~~5.~~ *3.* To drive a motor vehicle when the driver's clear view of the highway through the rear window or windows is otherwise obstructed.

C. Except as provided in § 46.2-1053, but notwithstanding the foregoing provisions of this section, no sun-shading or tinting film may be applied or affixed to any window of a motor vehicle unless such motor vehicle is equipped with a mirror on each side of such motor vehicle, so located as to reflect to the driver of the vehicle a view of the highway for at least 200 feet to the rear of such vehicle, and the sun-shading or tinting film is applied or affixed in accordance with the following:

1. No sun-shading or tinting films may be applied or affixed to the rear side windows or rear window or windows of any motor vehicle operated on the highways of this Commonwealth that reduces the total light transmittance of such window to less than thirty-five percent;

2. No sun-shading or tinting films may be applied or affixed to the front side windows of any motor vehicle operated on the highways of this Commonwealth that reduces total light transmittance of such window to less than fifty percent;

3. No sun-shading or tinting films shall be applied or affixed to any window of a motor vehicle that has a reflectance of light exceeding twenty percent;

4. Any person who operates a motor vehicle on the highways of this Commonwealth with sun-shading or tinting films that has a total light transmittance less than that required by subdivisions 1 and 2 of this subsection or a reflectance of light exceeding *twenty percent shall be guilty of a traffic infraction but shall not be awarded any demerit points by the Commissioner for the violation;*

5. Any person or firm who applies or affixes to the windows of any motor vehicle in Virginia sun-shading or tinting films that reduce the light transmittance to levels less than that allowed in subdivisions 1 and 2 of this subsection or that have a reflectance of light exceeding twenty percent shall be guilty of a Class 3 misdemeanor for the first offense and of a Class 2 misdemeanor for any subsequent offense;

D. The Division of Purchases and Supply, pursuant to § 2.1-446, shall determine the proper standards for equipment or devices used to measure light transmittance through windows of motor vehicles. Law-enforcement officers shall use only such equipment or devices to measure light transmittance through windows that meet the standards established by the Division. Such measurements made by law-enforcement officers shall be given a tolerance of minus seven percentage points.

E. No film or darkening material may be applied on the windshield except to replace the sunshield in the uppermost area as installed by the manufacturer of the vehicle.

~~D.~~ *F.* Nothing in this section shall prohibit the affixing to the rear window of a motor vehicle of a single sticker no larger than twenty square inches if such sticker is totally contained within the lower five inches of the glass of the rear window, nor shall subsection B of this section apply to a motor vehicle to which but one such sticker is so affixed.

~~E.~~ *G.* As used in this article: "front side windows" means those windows located adjacent to and forward of the driver's seat; "rear side windows" means those windows located to the rear of the driver's seat; "rear window" or "rear windows" means those windows which are located to the rear of the passenger compartment of a motor vehicle and which are approximately parallel to the windshield.

~~F.~~ *H.* Notwithstanding the foregoing provisions of this section, sun-shading material which was applied or installed prior to July 1, 1987, in a manner and on which windows not then in violation of Virginia law, shall continue to be lawful, provided that it can be shown by appropriate receipts that such material was installed prior to July 1, 1987.

~~G.~~ *I.* Where a person is convicted within one year of a second or subsequent violation of this section involving the operation of the same vehicle having a tinted or smoked windshield, the court, in addition to any other penalty, may order the person so convicted to remove such tinted or smoked windshield from the vehicle.

§ 46.2-1053. Equipping certain motor vehicles with sun-shading or tinting films or applications.—Notwithstanding the provisions of § 46.2-1052, a motor vehicle operated by or regularly used to transport any person with a medical condition which renders him susceptible to harm or injury from exposure to sunlight or bright artificial light may be equipped, on its windshield and any or all of its windows, with sun-shading or tinting films or applications ~~which are of a type approved by the Superintendent of State Police and~~ which reduce the transmission of light into the vehicle *to levels not less than thirty-five percent . Such sun-shading or tinting film when applied to the windshield of a motor vehicle shall not cause the total light transmittance to be reduced to any level less than seventy percent except for the upper five inches of such windshield or the AS-1 line, whichever is closer to the top of the windshield.* Vehicles equipped with such sun-shading or tinting films shall not be operated on any highway unless, while being so operated, the driver or an occupant of the vehicle has in his possession a certificate issued by the Superintendent of State Police authorizing such operation. The Superintendent shall issue such certificate only upon receipt of a signed statement from a licensed physician or licensed optometrist (i) identifying with reasonable specificity the person seeking the certificate and (ii) stating that, in the physician's or optometrist's professional opinion, the equipping of a vehicle with sun-shading or tinting films or applications is necessary to safeguard the health of the person seeking the certificate. Certificates issued by the Superintendent under this section shall be valid so long as the condition requiring the use of sun-shading or tinting films or applications persists or until the vehicle is sold, whichever first occurs. Such certificates shall permit the approval of any such vehicle upon its safety inspection as required by this chapter if such vehicle otherwise qualifies for inspection approval. In the discretion of the Superintendent, one or more certificates may be issued to an individual or a family. *The Division of Purchases and Supply, pursuant to § 2.1-446, shall determine the proper standards for equipment or devices used to measure light transmittance through windows of motor vehicles. Law-enforcement officers shall use only such equipment or devices to measure light transmittance through windows that meet the standards established by the Division. Such measurements made by law-enforcement officers shall be given a tolerance of minus seven percentage points.*

President of the Senate

Speaker of the House of Delegates

Approved:

Governor

APPENDIX B

INFORMAL OBSERVATIONS BASED ON EXPERIENCE IN DRIVING A VEHICLE TINTED TO THE MAXIMUM ALLOWED BY LAW IN VIRGINIA

A 1987 Chevrolet Caprice that had tinting films applied to the maximum allowed by state law (50% front side windows and 35% rear and rear side windows) was used to make these informal observations. The vehicle was driven and inspected at various times of day over a three-week period. A second Caprice with no window film was driven for comparison. The following informal observations were made.

The Effect of Window Tinting on the Performance of the Driver

During daytime driving, the reduced transmittance of the windows did not provide any noticeable visual impediment.

At twilight and at night, it was difficult to know whether the presence of window tinting was having an adverse effect on visual performance. It is, of course, impossible to know whether one has not seen something that would have been seen had the tinting films not been applied. The situations in which the tinting is most likely to be problematic—merging, passing, and backing—were rarely encountered at night.

The Effect of Window Tinting on Facial Communication

The most striking observation in this context was how situational were the adverse effects of the window tinting. During daytime hours and from a distance of about 20 ft, the ability to discern the direction of a driver's gaze varied enormously with the observer's position and the ambient lighting. For example, when parked in a well shaded location on a bright sunny day, the reflections of the sky through overhead leaves created a shimmering pattern of reflections on the driver's front side window that prohibited detecting whether a person sitting in the driver's seat was looking straight ahead or at the viewer who was about 20 ft away. Later in the day, the driver's direction of gaze was discernible from the same location.

The Effect of Window Tinting on Police Officer Safety

Similar effects were observed when approaching the car from the rear and looking inside. At some times of day, only the highest contrast article in the car, which was a white notepad, was clearly visible. At other times of day, the tinting did not seem to be that great an impediment to viewing the interior. Finally, depending on the position of the sun, it was found that one rear side window might allow a reasonable view of the interior, whereas the other overwhelmed the viewer with ambient reflections.

Unanticipated Effects of Window Tinting

The primary reason for driving and observing a car with tinted windows was to see whether there were obvious effects that could not be predicted from the existing literature or optical and visual principles. Such unanticipated effects were, in fact, quite noticeable.

Wrinkles in the Tinting Film

The tinting film created a visible rippling effect to everything viewed out of the rear window as a result of wrinkles that occurred wherever the film passed over a rear window heating element. Apparently, the film bulged a little as it passed over each heating element. Although annoying, it could not be concluded that it was safety hazard.

On the other hand, these rear window wrinkles did create scattered glare at night. When followed at night by a car with its headlights on, the heating elements became a source of glare for a circular area having a diameter of about 4 or 5 inches around each observed headlight. The heating elements seemed to glow within this area of scattered glare. It is likely that its occurrence in the tinted car was due to the wrinkling of the tinting film over the heating elements.

There was a small amount of wrinkling in the film in the right rear side window. This wrinkling was difficult to notice, and given its location, probably is of no consequence.

Scattered glare has been found to be a far worse impediment to visual performance than reduced transmittance. In the Rompe and Engel (1987) study, a 77.4% transmittance windshield with 1.2% haze was compared with windshields having varying degrees of transmittance but no haze. Haze increases scattered glare. In this simulator study, the 77.4% window with haze resulted in far worse target detection performance than the lowest transmittance window which was 40%. This decrement in performance was especially evident in the presence of a source of glare.

The tinted car had been tinted by a company recommended by representatives of the tinting industry. It seems likely that the tinting films had been applied with a better than average level of proficiency. Poorer applications would likely result in an increased incidence of wrinkles and scattered glare and their concomitant detrimental effects on visual performance.

State regulations require that tinting films must not have wrinkles, but what constitutes wrinkles is not well defined. Those on the rear window could not be observed from the outside and were only apparent in the distortions that they produced on objects viewed through this window. Thus, the presence of these wrinkles would be very difficult for a police officer to assess.

All window tinting studies conducted to date have used tinting films applied to flat glass windows without heating elements; thus, these studies are about "best-case" applications. The quality of a typical application has not been assessed.

The films in the tinted car interacted with polarized sunglasses. Rainbow-like patterns of light were observed in the windows of the car, and strange chromatic effects were noticed when observing outside objects. On one particular occasion just before sunset, the windows of passing cars viewed through the right front window appeared to change colors dramatically as the car approached and passed. When viewed through the untinted windshield these cars looked normal. The most disturbing effect was that these color changes were quite abrupt, and for this reason, drew attention unnecessarily. These effects did not occur without sunglasses or with a pair of unpolarized sunglasses. However, it is not known whether this effect is a general one or was specific to the particular tinting film.

Increased Interior Reflections in Rear Window

With passengers in the rear seat during daytime hours, the rear window reflected the passenger's images to a considerable degree. The magnitude of these reflections may have been due to the tinting films or to this make of car. Whether these interior reflections might present a hazard to safety cannot be concluded.